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THE ENERGY INDEX

Cardio-Vascular Energy as Indicated by the Arterial Pressure per Minute

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CARDIOVASCULAR ENERGY AS INDICATED BY THE ARTERIAL PRESSURE PER MINUTE

JOSEPH H. BARACH, M.D.
PITTSBURGH, PA.

Thus far we have had no reliable method for estimating the functional capacity of the heart, although much has been written on the work done along this line, nor have we a certain and easily applicable method for determining the velocity of the blood. Aside from these, we need an index to the intravascular tension and to the amount of energy which the circulatory system expends in the course of a minute, an hour or a day. We need these particularly when we are dealing with cases in which the heart or the blood-vessels are endangered.

The best means which we have at present for determining the expended energy of the circulatory system is the use of the mercury manometer. With this instrument, by the auscultatory method, we can accurately measure the arterial pressure at the time of systole and at the time of diastole of the heart. The systole gives us the energy factor in the work of the heart. The diastole gives us the energy factor in the peripheral resistance. From the pulse-rate we know how many systoles and how many diastoles to each minute there are in the arterial tree.

For example, if the maximum pressure is 120 mm. Hg, the minimum pressure 70 mm. Hg and the pulse-rate 72 per minute, the exertion in one minute would be:

In systole	120 mm. Hg	× 72 =	8,640 mm. Hg
In diastole	70 mm. Hg	× 72 =	5,040 mm. Hg
In both	190 mm. Hg	× 72 =	13,680 mm. Hg

This, according to the most practical means we have, represents the total effort exerted per minute by the cardiovascular system. We may call it the energy index or S. D. R. index.[1]

The advantages of this method of indicating the expended energy of the cardiovascular system are that

1. This method for obtaining an index to the cardiovascular energy is so simple that when its utility occurred to me I scarcely thought it possible that it had not been suggested long ago. In a search through the literature at my command, I have not, however, been able to find it. Certain it is that it is not a recognized method, which I believe it deserves to be.

we are not deceived by the high maximum pressure when it is combined with a relatively low minimum pressure, or vice versa. It is a well-established clinical fact that the two pressures do not always tend in the same direction, and that one or the other may rise or fall.

Also in this method, we do not neglect to consider the pulse-rate, which is an absolutely necessary element in properly estimating the expended energy of the cardiovascular system in a given length of time.

Judging by the clinical reports of the present day, the pulse-rate heretofore has largely been left out of this consideration. It is true that the number of pulse-beats per minute is not the greatest factor in producing high blood-pressure; but that each ventricular systole plays its part in the total blood-pressure is obvious, and that a greater number of systoles represents a greater total energy expenditure and a greater wear and tear is also clear enough. It is the last-mentioned factor particularly which we may aim at estimating in our clinical work, and for which the S. D. R. index is most useful.

If we were to take into consideration the duration of the systole and the diastole in every case, our calculations would be still more representative of the total cardiovascular energy. According to Tigerstedt, in the normal person the average duration of the systole is from 0.19 to 0.382 second, and the diastole is 0.4 second. But the cases in which this would be an important clinical factor are the exceptions, although with the recording instruments, the actual time of both systole and diastole can be determined readily. On the other hand, absolute values would not necessarily aid us greatly in our diagnosis, prognosis or treatment. What we need for our every-day work is an index, and a point for the normal; after that our values are just as useful, so long as they are relatively true.

How enlightening this method is may be inferred from the findings in a series of 289 young men between the ages of 15 and 30 years (Table 1). There were 41 cases in which the maximum pressure ranged between 110 and 120 mm. Hg. Ordinarily, we should pass this over without much consideration; but on comparing the extremes of cardiovascular energy in this series, and in

the subsequent ones, we soon see that the maximum pressure alone, on which most reliance has heretofore been placed, gives us not even an inkling of what is going on.

TABLE 1.—TOTAL ENERGY INDEX IN TWO HUNDRED AND EIGHTY-NINE CASES

Group	Total No. Cases	Maximum Blood-Pressure mm. Hg.	Extreme Instances	Maximum	Minimum	Pulse	Total Energy Index mm. Hg. per Min.
1	41	From 110 to 120	Case A	115	52	72	12,024
			Case Z	110	88	124	24,552
2	99	From 120 to 130	Case A	124	68	68	13,056
			Case Z	125	100	120	27,120
3	76	From 130 to 140	Case A	138	90	64	14,592
			Case Z	132	118	132	33,000
4	43	From 140 to 150	Case A	142	85	60	15,436
			Case Z	148	98	120	29,520
5	26	From 150 to 160	Case A	150	90	76	18,240
			Case Z	150	115	88	27,440
6	4	From 160 to 170	Case A	164	110	68	18,632
			Case Z	162	80	120	29,040

Case A and Case Z in each group are examples of the extreme cases in that group. Whether in Case Z of each of the groups the increased activity was physiologic or not, temporary or constant, is to be determined by reexamination and by other means. That there was present at the time of the examination a marked increase of activity over Case A, and how much the increase amounts to, can be determined best by utilizing the S. D. R. index—the energy index.

In Table 2 is presented a series of 116 normal cases in which the pulse-rate did not exceed 90 beats, and the minimum pressure did not exceed 100 mm. Hg.

TABLE 2.—TOTAL ENERGY INDEX IN ONE HUNDRED AND SIXTEEN NORMAL CASES

Maximum Pressure mm. Hg.	No. of Cases	Average Total Energy, mm. Hg.
From 100 to 120	16	15,196
From 120 to 130	59	17,086
From 130 to 140	22	17,450
From 140 to 150	12	18,722
From 150 to 160	7	20,705

Judging by Table 2 and in the light of what is known to be the normal maximum, the normal minimum pressure and the pulse-rate, it appears that the highest energy index in the normal person is close to 20,000 mm. Hg per minute.

For the sake of simplicity, I believe that it does not involve too great an error to strike off the last two figures of our totals and to say that in a given case the energy index is 151 or 170, as the first two total energy indexes in the series would show. Or we may designate the degree of hypernormal expenditure by the percentage of increase over 20,000. Thus a case with a total energy index of 30,000 may be designated as showing a 50 per cent. increase, and so on.

I have picked out of my records of the past year ten cases of advanced cardiovascular and renal involvement. These patients were all seriously ill, and recognized as such from the start. Up to the present time five of them have had apoplectic strokes. Cases 4, 8, 9 and 10, which are the younger patients of the series, each show an extraordinary amount of total energy expenditure per minute, and judging by their present symptoms, it seems only a matter of a comparatively short time until either the heart or a blood-vessel will give way, although we do occasionally see patients with very high pressure maintaining their health for long periods.

TABLE 3.—THE TOTAL ENERGY INDEX IN HYPERTENSION

Case No.	Age	Max.	Min.	Pulse-Rate	Total Energy	Remarks
1	66	182	100	74	20,868	Six months later, cerebral hemorrhage.
2	63	164	100	90	23,760	Eight months later, cerebral hemorrhage.
3	69	192	176	66	24.288	Six months later, cerebral hemorrhage.
4	50	235	120	84	29,820	Symptoms of threatened cerebral hemorrhage.
5	51	235	120	84	29,820	Six months later, cardiac failure.
6	59	220	140	84	30,240	One month later, cerebral hemorrhage.
7	54	200	140	108	36,720	One month later, cerebral hemorrhage.
8	52	220	160	96	36,480	Symptoms of cerebral angiospasm
9	35	180	145	120	39,000	Chronic nephritis; albuminuric retinitis.
10	56	280	140	120	50,400	Serious symptoms of cerebral arteriosclerosis.

A review of the figures in Table 3 makes it at once apparent how important it is that we include the complete triad—the maximum pressure, the minimum pressure and the pulse-rate—in order that we may obtain a definite idea of the cardiovascular energy expended, and of the strain under which the heart and the blood-vessels are laboring.

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